Agricultural
Research
Service

STRUCTURAL TREATMENTS

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Structural Treatments

- Food facilities have historically relied on fumigation or heat treatments to reduce or eliminate stored-product insect infestations of building structure, equipment, and product

Food Facilities: Wheat and Rice Mills

- Complex structures consisting of…
  - Bulk storage elevator/bins
  - Mill
  - Milled bulk storage
  - Packaging
  - Warehouses
- Stored-product insect infestations can occur inside and outside all of these structures

Infestation of Mill Structure

- Within mill, some species can exploit grain and grain fractions that accumulate in cryptic locations within equipment and building structure

Integrated Pest Management

- Preventing and eliminating food accumulations – sanitation and structural modifications
- Reducing potential for colonization – exclusion and treating surfaces
- Eliminating established infestations – commodity and structural fumigations and heat treatments

Structural Treatments

- Fumigation: applying an insecticide that is active in the gaseous state
  - Methyl bromide, sulfuryl fluoride, phosphine
- Heat treatment: raising the temperature above the lethal level for insects

Structural Treatments

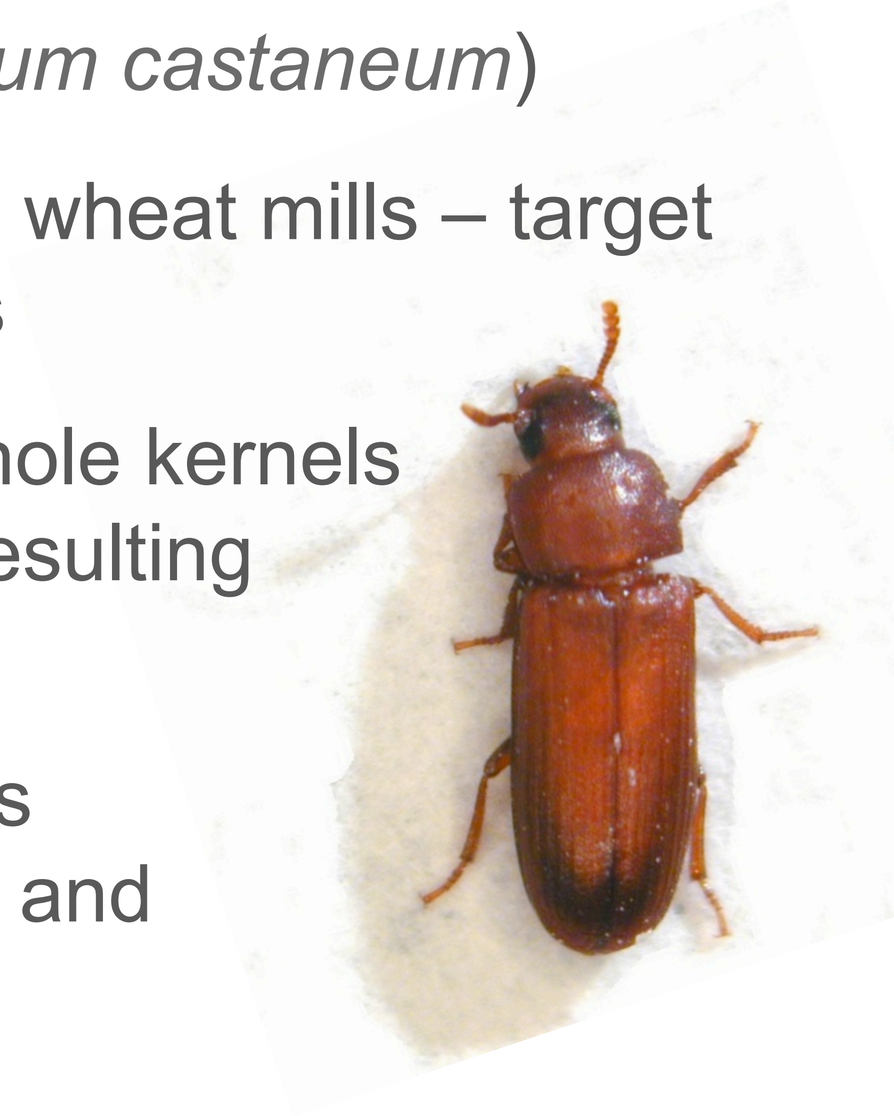
- Ability to penetrate into the hidden areas exploited by stored product insects
- Highly toxic, but limited data on how effective they are in complex commercial facilities
- No residual activity, so rapid recolonization possible


Fumigants for Mill Structures

- Methyl bromide
  - Historically most widely used
  - Phasing out worldwide under the Montreal Protocol on Substances that Deplete the Ozone Layer
- Phosphine
  - Used for commodity treatments
  - Corrosive effects limit use in mills
- Sulfuryl fluoride
  - Limited egg mortality may impact efficacy
  - Adopted by some rice mills

Red Flour Beetle

- Red flour beetle (*Tribolium castaneum*)
- Primary pest in rice and wheat mills – target for structural treatments
- Can utilize damaged whole kernels and different fractions resulting from milling process
- Exploits cryptic locations within building structure and equipment - moves into finished product



Using Pheromone Traps to Document Treatment Efficacy

- Standardized program (same numbers of traps in same locations over time)
- Provides feedback on management program – quality control
- Indirect measure of insect abundance and distribution
- Can be used to develop action and risk thresholds

What is the impact of different structural treatments on stored product pest populations in food facilities?

Evaluation of Structural Treatments

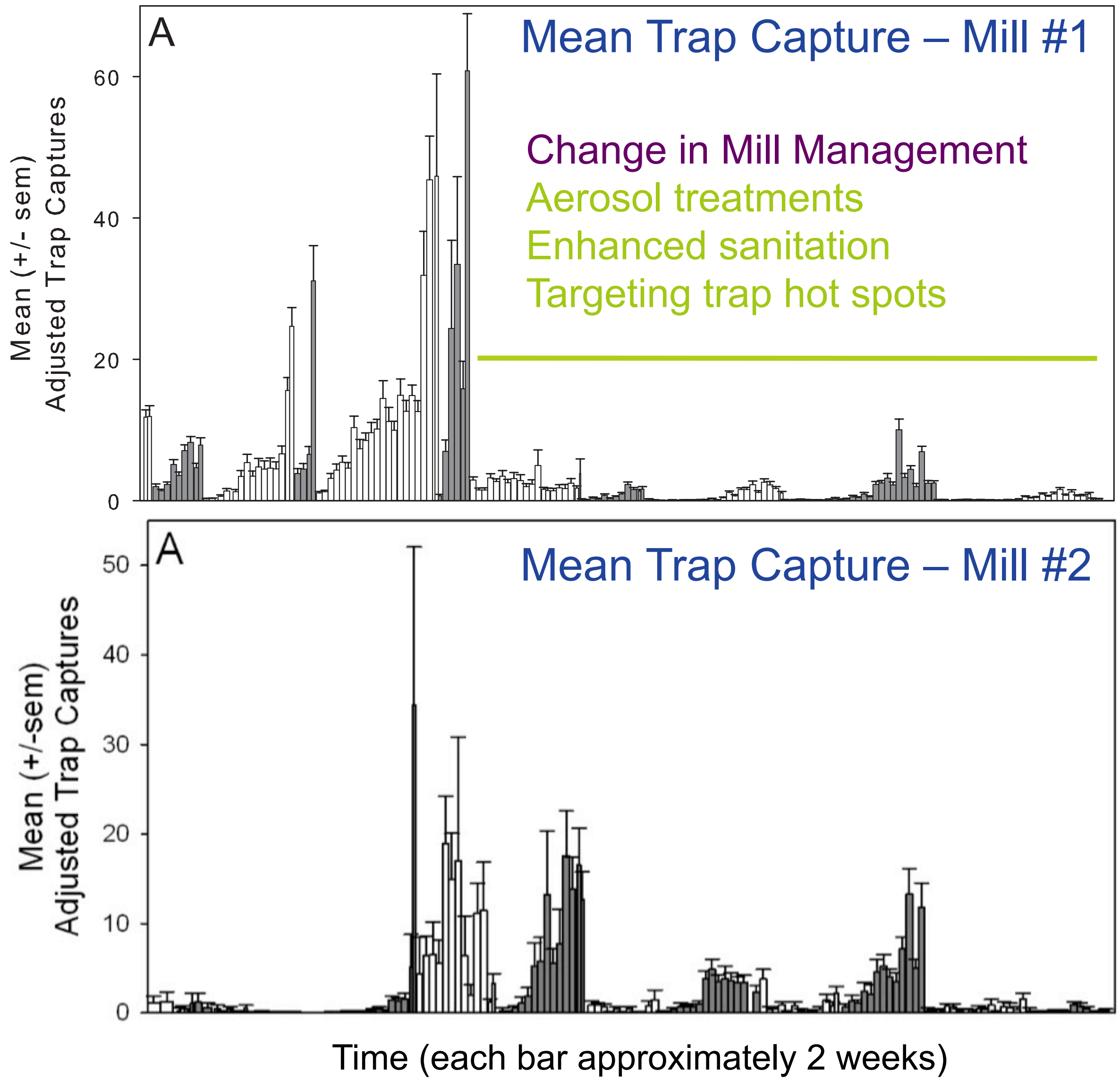
- Difficult to…
  - Replicate – variation among facilities, within a facility over time, and among treatment applications
  - Isolate impact of treatment from influence of other management practices within facility
  - Accurately measure pest population levels
  - Obtain information on pest activity from commercial food facilities

Evaluation of Structural Treatments

- Need to look at a relatively large number of treatments to develop an understanding of the average effectiveness of a treatment
- We have been collecting and analyzing this type of data from commercial food facilities

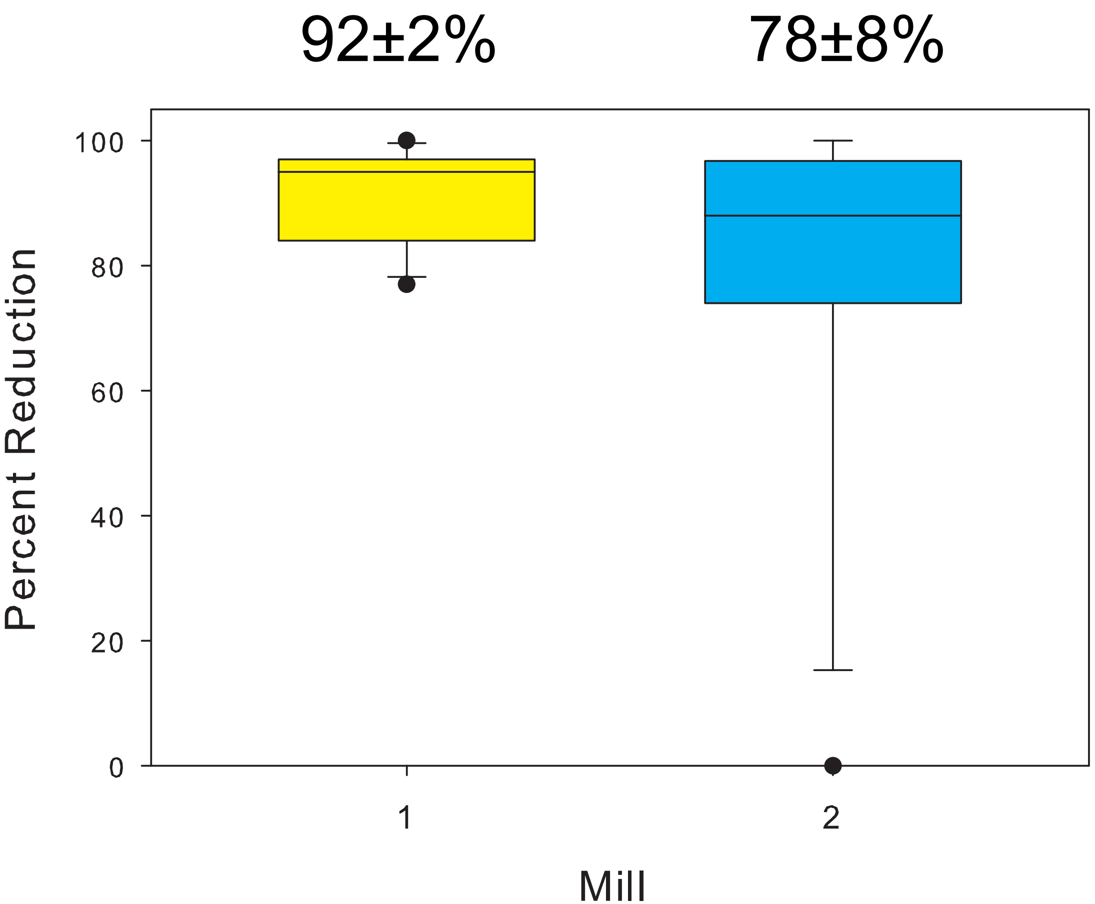
Determine long term patterns in red flour beetle captures and impact of treatments

Example: two wheat mills – RFB captures in traps over time, periods between fumigations indicated by color of bar



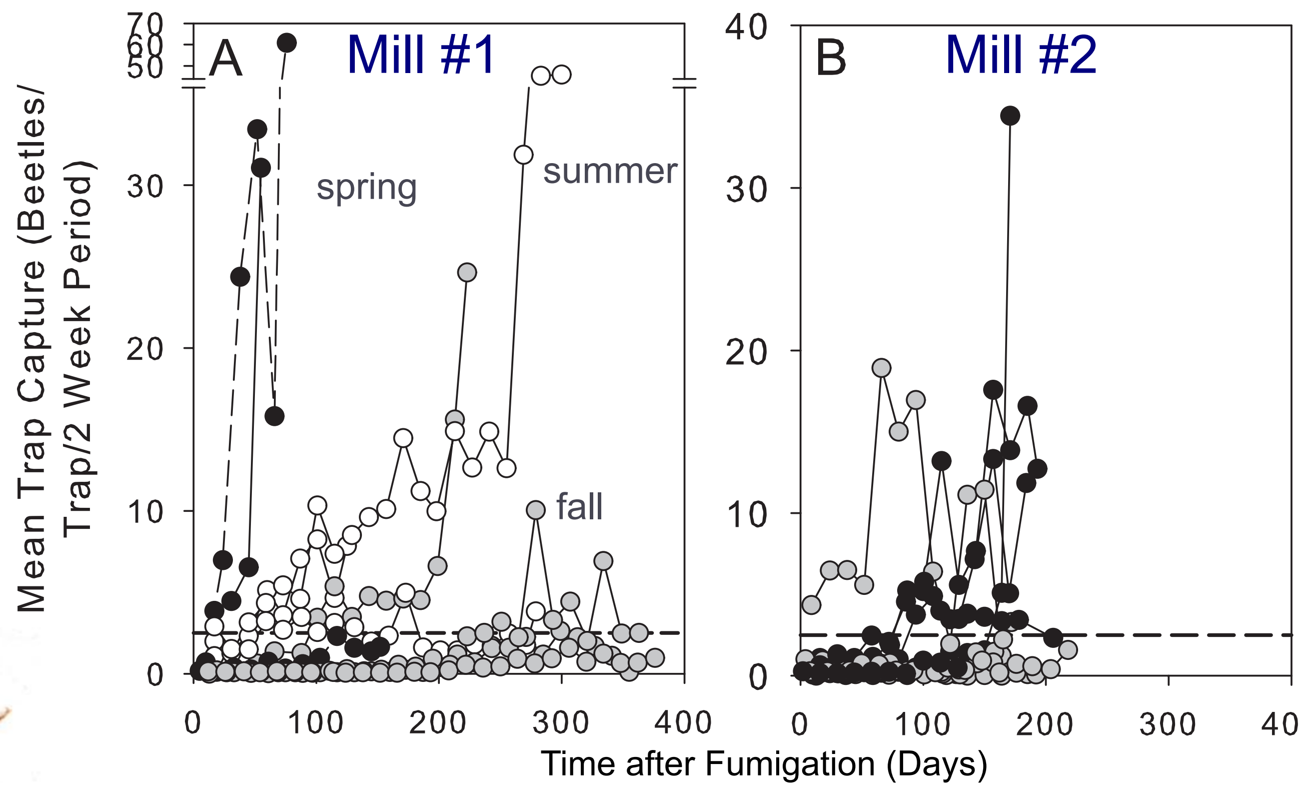
Can then summarize the variation and calculate the average reduction in beetle captures following fumigation

85±5% reduction in beetles/trap/period (23 fumigations, 2 mills, >6 years)



Can rework the data to evaluate the rebound in beetle captures after treatment

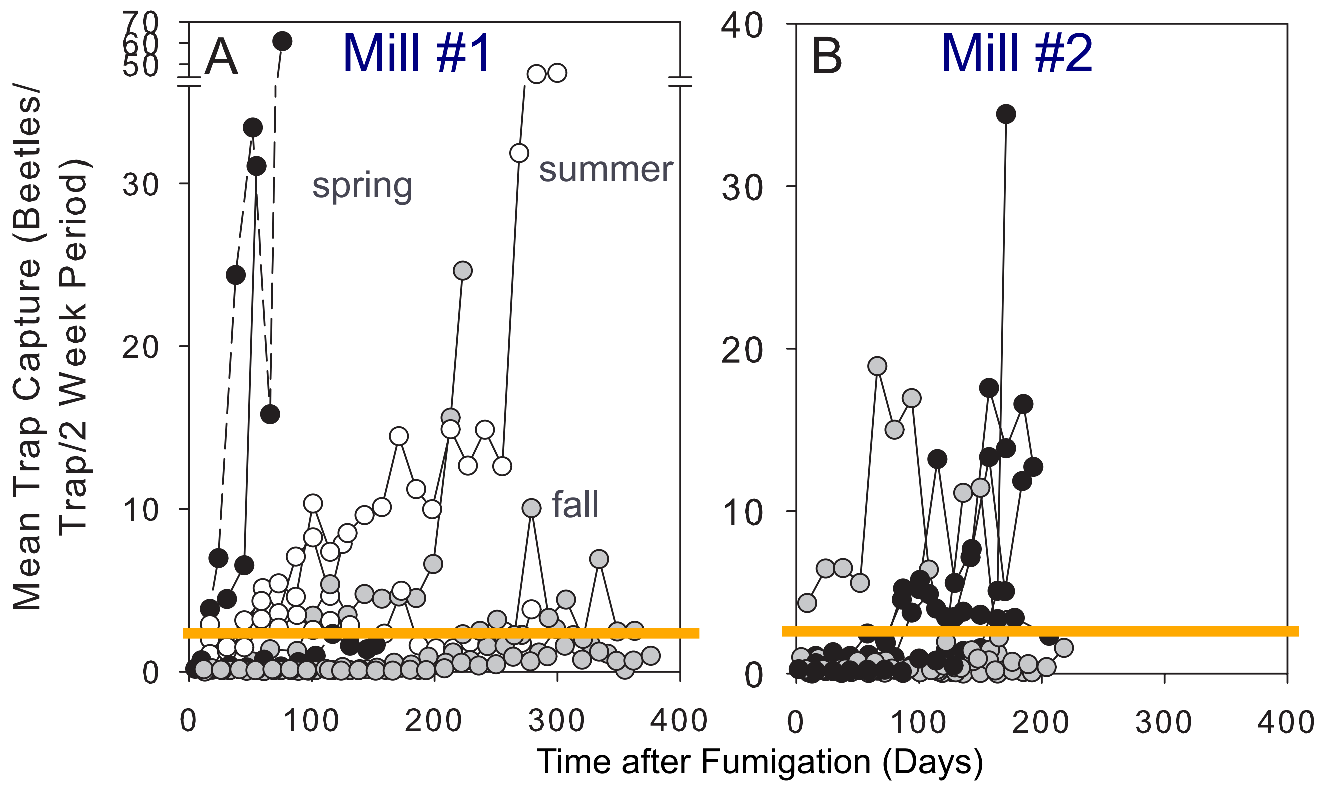
Rebound impacted by treatment survival, immigration, and population growth rate (management tactics and environmental conditions)



Campbell et al. 2010b

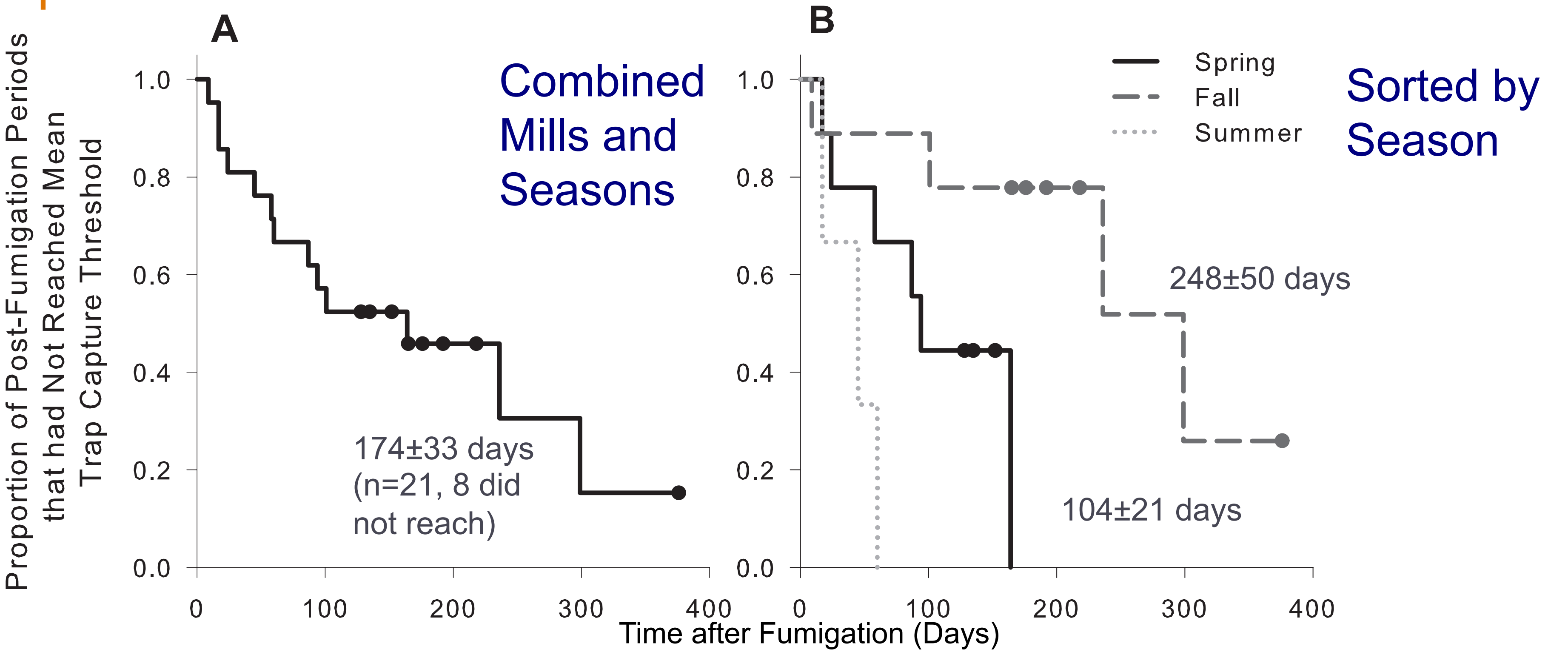
Develop a threshold of beetle captures to use in evaluating the treatments

Developed threshold value to compare rebound rates – 2.5 beetles/trap/2 wk period (= median trap capture prior to fumigation)

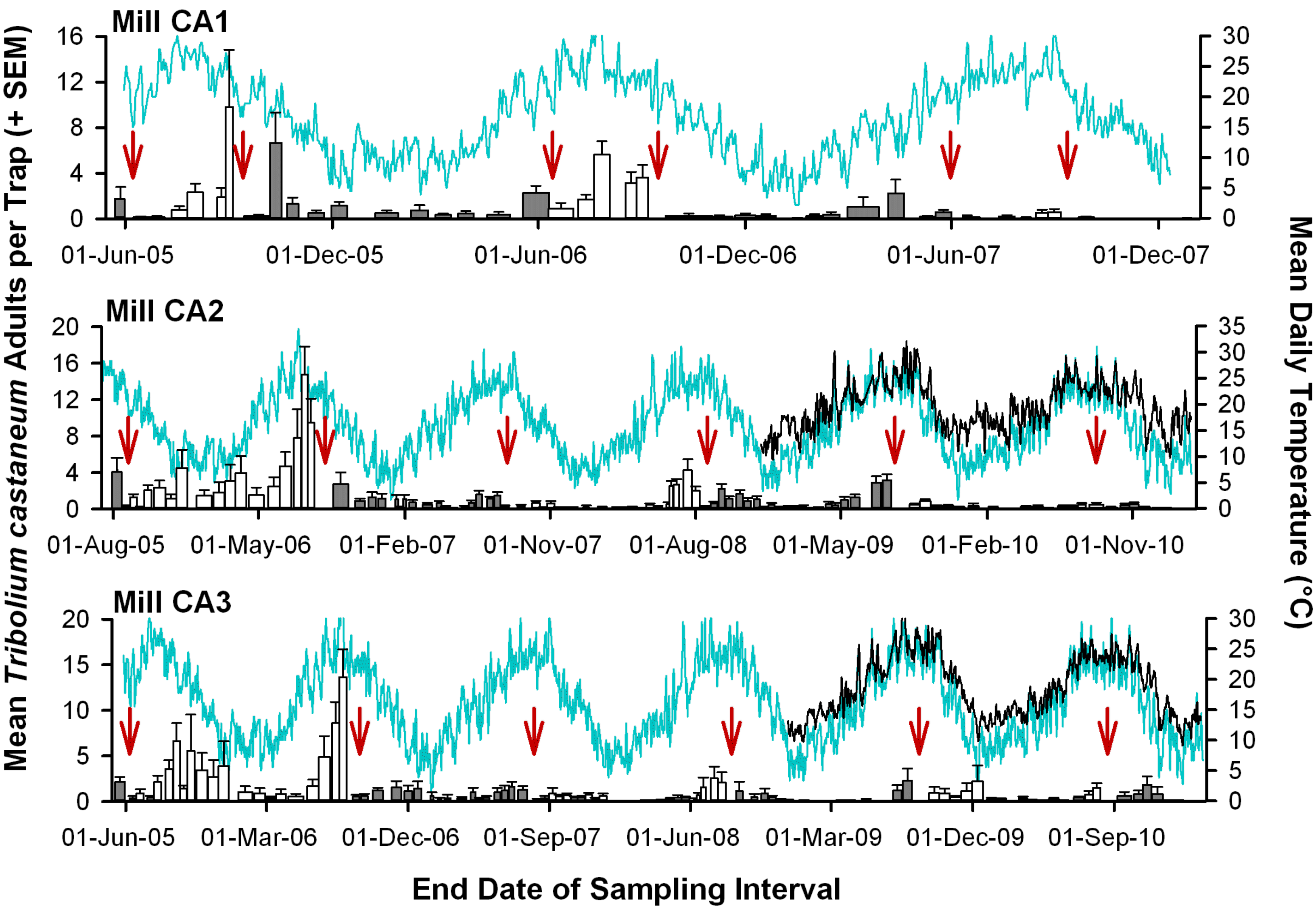


Evaluate the time to reach threshold after treatment to compare efficacy of structural treatment, facility type, and season

Plot proportion that have not reached threshold (and average time) – quicker the line reaches zero the quicker the rebound



Similar type of data collected at rice mills



Fumigation Efficacy in Rice Mills

- 66 ± 6% reduction in RFB captures from pre- to post-fumigation monitoring periods
  - 2.9 ± 0.7 RFB / trap before fumigation
  - 0.8 ± 0.3 RFB / trap after fumigation
- Rebound in RFB captures to the 2.5 RFB per trap per 2 week monitoring period was 270 ± 31 days (combined mills and seasons)

Buckman et al. 2012

Meta-analysis

Because of all this variation among treatments and the potential impacts of facility type and season need a larger data set and analysis that can take this into account

Meta-Analysis

- Objective and quantitative methodology for synthesizing individual studies into overall finding
- Widely used in fields of medicine, social sciences, and ecology, but not in evaluation of pest management
- Primarily to evaluate effect size (treatment relative to control)

Meta-Analysis Methods

Meta-Analysis: Step 1, Identify Relevant Variables

- Information from monitoring programs in operational food facilities
- Treatments made by commercial applicators using established protocols
- Monitoring data available before and after treatment
- Trapping data based on Dome traps with pheromone lures for *Tribolium* spp. and kairomone lures

Meta-Analysis: Step 1, Identify Relevant Variables

- Efficacy evaluated based on change in beetle captures in traps following treatment
  - *Tribolium castaneum* (RFB) and *T. confusum* (CFB)
- Rebound after treatment will be evaluated in a subsequent analysis
- Evaluate how structural treatment type, facility type, and insect species effect efficacy

Meta-Analysis: Step 1, Identify Relevant Variables

1. **Mean number of beetles captured per trap**
2. Proportion of traps that captured one or more beetles per standardized sampling segment
3. Proportion of traps that captured more than the threshold level of 2.5 beetles/trap/segment
4. Change in capture of beetles from one monitoring period to the next at individual trap level

Meta-Analysis: Step 2, Locate Relevant Research

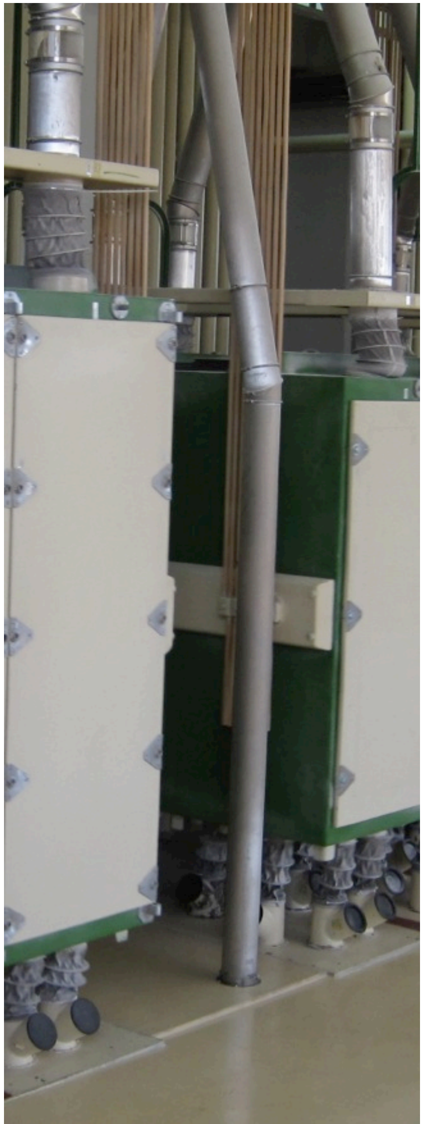
- Final dataset contained
  - 39 facilities
    - 29 wheat flour mills
    - 8 rice mills
    - 1 pasta plant
    - 1 rice mill packing plant
  - 111 treatments
    - 48 methyl bromide (MB)
    - 41 sulfuryl flouride (SF)
    - 10 heat treatments

Meta-Analysis: Step 2, Locate Relevant Research

- Quality of monitoring dataset
  - Average number of traps: 21±2 (7 to 55 traps)
  - Average sampling interval: 15±1 days (7 to 28 days)
  - Average total sampling period: 757±155 days (74 to 4,696 days)
- Captures converted to number of beetles captured per trap per 2 week sampling interval

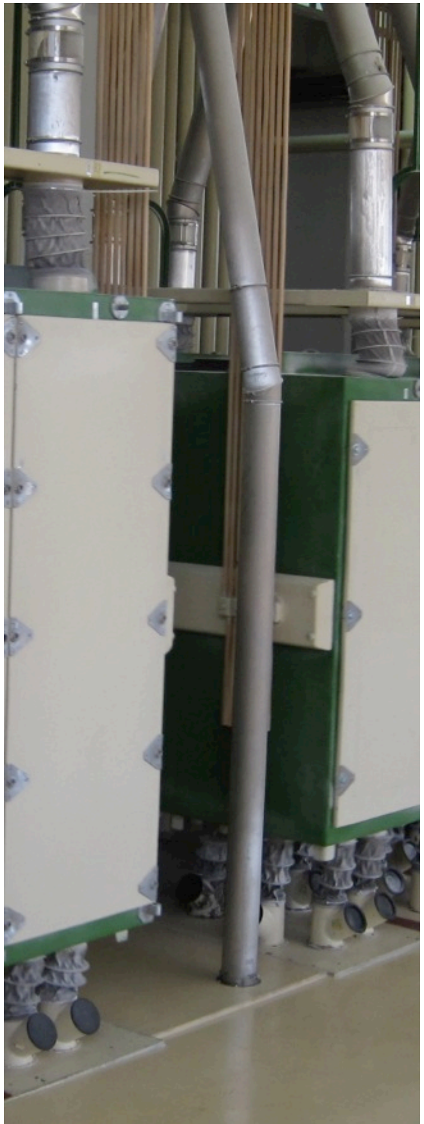
Results

Evaluation at Facility Level



- Mean number of beetles captured per facility:
  - 1.5±0.1 beetles/trap/2 wks
- Wheat mills tended to have more beetles captured than rice mills (Q_b=6.0, df=1, P=0.015)
  - wheat mills (n=29): 1.8±0.2 beetles/trap/2 wks
  - rice mills (n=8): 1.1±0.2 beetles/trap/2 wks

Evaluation at Facility Level



- Change in captures from one monitoring period to the next in absence of structural treatment
  - 0.07±0.02 beetles/trap/2 wks
  - Significantly different from no change (Z=2.77, P=0.006)
- No difference between wheat mills and rice mills (Q_b=0.04, df=1, *P*=0.83), and both facility types were significantly different from null

Evaluation at Individual Treatment Level

- Immediately prior to treatment the mean number of beetles captured was 1.6±0.1 beetles/trap/2 wks
- 6% of treatments had zero captures immediately prior to treatment
- Average duration of a pre-treatment sampling period was 13.7±0.8 days

Evaluation at Individual Treatment Level


- Immediately after treatment the mean number of beetles captured was 0.1±0.0 beetles/trap/2 wks
- 25% of treatments had no beetle captures in the first monitoring period after treatment
- Average duration of the first post-treatment sampling period was 13.8±0.8 days

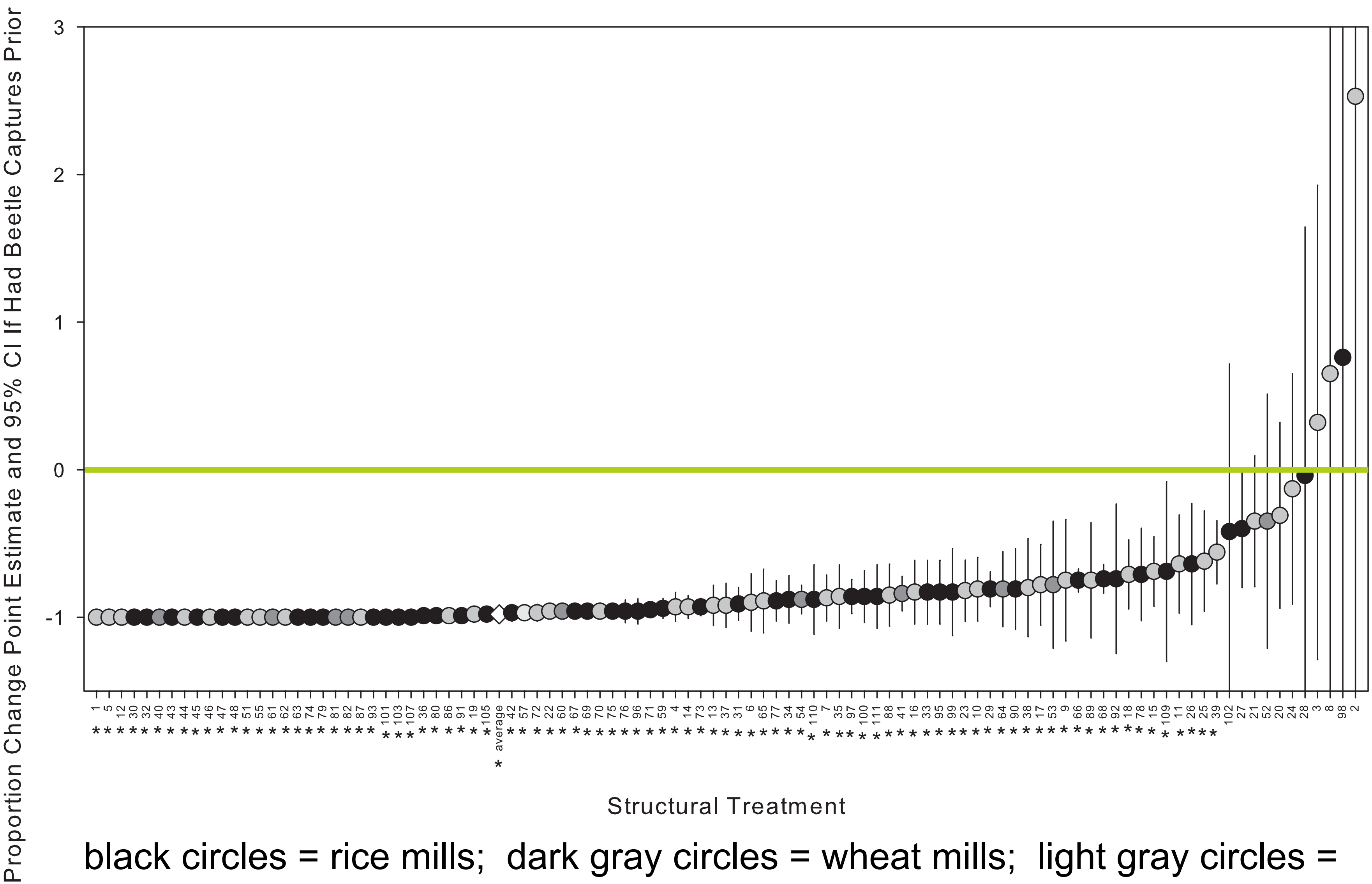
Reduction in Beetle Captures

- This resulted in a mean change in beetle captures if the trap had captures prior to treatment of
  - -99±0% (n=100) using the random meta-analysis model
- However, variation among individual treatments with some not causing a significant reduction

Reduction in Beetle Captures

- Structural treatment type (MB, SF, heat) did not have a significant impact (Q_b=1.36, df=1, P=0.507)
- Facility type did have a significant impact (Q_b=11.55, df=2, P=0.003):
  - Wheat mills (-0.98±0.00 (n=65)) significantly greater reduction than rice mills (-0.94±0.01 (n=31))

Reduction in Beetle Captures



black circles = rice mills; dark gray circles = wheat mills; light gray circles = other; white diamond = mean

Conclusions

- First comprehensive evaluation of structural treatments
- Results provide some unique insights into these treatments and their impact on pest populations
  - Impact of facility type (and pest population distribution and dynamics)
  - In terms of immediate reduction in beetle captures MB, SF, and heat gave similar efficacy

Conclusions

- Need to still evaluate differences in rebound between the different treatment
- Meta-analysis of large numbers of structural treatments provides an estimate of effect size, or efficacy, that is less prone to bias

Questions

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